

CAN MODULE

5 Cross-Reference to Related Application:

This is a continuation of copending International Application PCT/DE99/02104, filed July 8, 1999, which designated the United States.

10 Background of the Invention:

Field of the Invention:

The present invention relates to a controller area network (CAN) module.

- 15 CAN modules, as indicated by the designation itself, are required in so-called controller area networks. With the aid of CANs, control devices such as microcontrollers, for example, can be connected to or networked with other control devices, actuators, sensors, etc. A CAN bus connecting the
- 20 individual components may contain a single line; data can be exchanged via the CAN bus between the components connected thereto, it being possible for the data exchange to be carried out very reliably and efficiently.

The CAN modules are generally constituents of the components which can be networked via the CAN bus, and regulate the data traffic effected via the CAN bus.

5 One possible practical configuration of a CAN module is described for example in the book published by Siemens AG and entitled "C167 Derivatives, 16-Bit CMOS Single-Chip Microcontrollers, User's Manual 03.96, Version 2.0" (order No. B158-H6651-G1-X-7600) on pages 23-1 to 23-20.

10 CANs are becoming more and more widespread, and, moreover, more and more microcontrollers are being equipped with CAN modules as standard. For certain applications, it may even
15 prove to be favorable if a unit that is to be networked can be connected to other components via a plurality of CAN buses. In this case, a plurality of CAN modules are simply provided in the relevant component.

Although technically the provision of a plurality of CAN
20 modules in a unit to be networked can readily be realized, it is relatively costly owing to the relatively complicated configuration of the CAN modules. Moreover, a great deal of chip area is required when accommodating the CAN modules in an integrated circuit.

This is a disadvantage and, understandably, it would be extremely desirable to eliminate it.

Summary of the Invention:

5 It is accordingly an object of the invention to provide a CAN module that overcomes the above-mentioned disadvantages of the prior art devices of this general type. The present invention is based on the object, therefore, of finding a possible way of enabling a component that is to be networked via a CAN to
10 be connected to a plurality of CAN buses simultaneously with minimal outlay.

With the foregoing and other objects in view there is provided, in accordance with the invention, a controller area
15 network (CAN) module containing a plurality of sets of storage elements for storing a plurality of sets of data representing different states of the CAN module.

Accordingly, a plurality of sets of storage elements for
20 storing a plurality of sets of data representing different states of the CAN module are provided in the CAN module.

As a result, at least those parts of the CAN module which are subject to little capacity utilization, such as, by way of
25 example, that part (the so-called bit stream processor (BSP)) of the CAN module which is responsible for adherence to the

CAN protocol, can be utilized as a shared component for a plurality of CAN buses. Such shared utilization of at least parts of the CAN module enables the outlay that has to be expended in order to connect a component that is to be
5 networked to a plurality of CAN buses to be reduced to a minimum.

In accordance with an added feature of the invention, there is provided a first CAN node, a second CAN node, and components
10 whose state is represented by the sets of data stored in the sets of storage elements and are jointly utilized components that can be connected alternately to one of the first CAN node and to the second CAN node.

15 In accordance with an additional feature of the invention, the jointly utilized components are normally components whose capacity utilization is low.

In accordance with another feature of the invention, the
20 jointly utilized components include a component which ensures that a CAN protocol is adhered to.

In accordance with a further feature of the invention, the sets of storage elements contain a first storage element set
25 and a second storage element set. And including a first multiplexer through which the components whose state is

represented by the sets of data stored in the sets of storage elements can be connected to one of the first storage element set and the second storage element set.

5 In accordance with a another added feature of the invention, a second multiplexer is connected to the first CAN node and the second CAN node, and through the second multiplexer, the jointly utilized components can be connected to one of the first CAN node and to the second CAN node.

10 In accordance with another mode of the invention, the jointly utilized components whose state is represented by the sets of data stored in the sets of storage elements are connected to the first storage element set through the first multiplexer.

15 And the jointly utilized components are connected to the first CAN node via the second multiplexer, if, on a part of the first CAN node, a request to access the jointly utilized components is present.

20 In accordance with an added mode of the invention, the jointly utilized components whose state is represented by the sets of data stored in the sets of storage elements are connected to the second storage element set through the first multiplexer.

And the jointly utilized components of the CAN module are
25 connected to the second CAN node through the second multiplexer, if, on a part of the second CAN node, a request

to access the jointly utilized components of the CAN module is present.

In accordance with a concomitant feature of the invention,

- 5 possible reactions of the jointly utilized components to requests on the part of the first CAN node and the second CAN node are determined in advance and buffer-stored until a relevant request occurs.

- 10 Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in a CAN module, it is nevertheless not intended to
15 be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

- 20 The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

Brief Description of the Drawing:

The figure of the drawing is a block diagram, partially showing a configuration of a CAN module according to the invention.

Description of the Preferred Embodiments:

A controller area network (CAN) module, described in more detail below, is part of a microcontroller which can be networked with other control devices (for example microcontrollers, too), actuators or sensors via a plurality of CAN buses (CAN nodes). It is distinguished by the fact that it has a plurality of sets of storage elements for storing a plurality of sets of data representing different states of the CAN module.

This makes it possible for the CAN module or parts thereof to be switched back and forth between different states, which in turn opens up the possibility of using the CAN module or parts thereof alternately for operating with a plurality of CAN buses.

The states represented by the data sets which can be stored in the plurality of sets of storage elements are, in particular, the states of components of the CAN module which have low capacity utilization. In the example considered in the

present case, data representing different states of the so-called bit stream processor are stored in the plurality of sets of storage elements. As a result, the relevant bit stream processor can be used for a plurality of CAN buses.

- 5 This proves to be particularly advantageous because the bit stream processor is one of the largest and most complicated constituents of the CAN module and the fact that it can be used for a plurality of CAN buses makes it possible to achieve a particularly pronounced saving of chip area.

10 It shall already be pointed out at this early stage that there is no restriction to the effect of only using the bit stream processor in the above-described manner for a plurality of CAN nodes. In principle, the procedure as described can
15 additionally or alternatively be effected with other components of the CAN module as well.

The above-mentioned bit stream processor is part of the so-called protocol machine of the CAN module. The protocol
20 machine forms, as it were, the interface between the CAN module and the CAN bus; as indicated by the term itself, it regulates the data traffic via the CAN bus taking account of the CAN specification.

The protocol machine of the CAN module also contains a so-called bit timing logic (BTL) in addition to the bit stream processor (BSP).

5 The BTL unit is connected directly to the CAN bus. It is responsible, in particular, for producing synchronization with the data stream (bit stream) transmitted via the CAN bus and for ensuring the reception and sending of data via the CAN bus.

10 The BSP unit (connected upstream of the BTL unit) reacts to the data received by the BTL unit and initiates as required the sending of data that are to be sent by the BTL unit. In addition, it ensures (in particular by corresponding driving
15 of the BTL unit) adherence to the CAN protocol during the sending and receiving of data by the BTL unit.

As has already been mentioned above, the BSP unit is used as a shared BSP unit for a plurality of CAN buses. The way in
20 which this can be realized in practice will now be described with reference to the figure. In the illustration in the figure and the description referring thereto, it is assumed that two CAN buses, namely a first CAN bus A and a second CAN bus B are operated by the BSP unit BSP. However, it shall
25 already be pointed out at this early stage that there is no restriction to the number two. On account of its low capacity

utilization, the BSP unit BSP can also be used as a shared component for more than two CAN buses.

Primarily on account of the synchronization which it has to carry out, the BTL unit is usually subject to high capacity utilization and, therefore, cannot normally be used, or at any rate not with a tenable outlay, as a shared BTL unit for the plurality of CAN buses. Therefore, in the example considered, a dedicated BTL unit is provided for each CAN bus, the BTL unit assigned to the first CAN bus A is designated by BTL A, and the BTL unit assigned to the second CAN bus B is designated by BTL B. Given a sufficiently high CPU clock frequency, however, it is also possible for a single BTL unit to be used jointly for the two or more CAN bus.

The (single) BSP unit BSP contains a logic section 1, a first set of storage elements 2, a second set of storage elements 3, a control section 4, a first multiplexer 5, and a second multiplexer 6.

The logic section 1 is the actual BSP unit. The way in which the system reacts to what events or states is defined in the logic section 1. The reaction of the logic section 1 depends, inter alia, on its own state. The data representing the state of the logic section 1 are stored in the two storage element sets 2, 3, the data stored in the first storage element set 2

representing that state of the logic section 1 which the latter has in its function as the BSP unit assigned to the first CAN bus A (i.e. node Node A) or to the first BTL unit BTL A, and the data stored in the second storage element set 3

5 representing that state of the logic section 1 which the latter has in its function as BSP unit assigned to the second CAN bus B (i.e. node Node B) or to the second BTL unit BTL B.

The logic section 1 operates in a manner taking account of the

10 data stored in the first storage element set 2 if and as long as it is necessary to react to a request or action by the first CAN bus A or the first BTL unit BTL A. A the logic section 1 operates in a manner taking account of the data stored in the second storage element set 3 if and as long as

15 it is necessary to react to a request or action by the second CAN bus B or the second BTL unit BTL B.

The data set that is taken into account by the logic section 1 when it is operating depends on the first multiplexer 5. Via

20 the first multiplexer 5, the logic section 1 can be connected optionally to the first storage element set 2 or to the second storage element set 3 and can thereby be put alternately into the state that is to be assumed for operating the first CAN bus A or the first BTL unit BTL A and into the state that is

25 to be assumed for operating the second CAN bus B or the second BTL unit BTL B.

The first multiplexer 5 is driven by the control section 4.

The control section 4 is connected to the BTL units BTL A and BTL B and is informed by the latter when they require a

5 connection to the BSP unit BSP. If the control section 4 receives a BSP request from the first BTL unit BTL A, then the control section 4 drives the first multiplexer 5 in such a way that the logic section 1 is connected to the first storage element set 2. If the control section 4 receives a BSP request from the second BTL unit BTL B, then the control section 4 drives the first multiplexer 5 in such a way that the logic section 1 is connected to the second storage element set 3.

15 The control section 4 also drives the second multiplexer 6. Via the second multiplexer 6, the logic section 1 can be connected optionally to the first BTL unit BTL A or to the second BTL unit BTL B and can thereby communicate alternately with the first BTL unit BTL A and the second BTL unit BTL B, 20 that is to say alternately operate the first CAN bus A and the second CAN bus B.

In this case, the control section 4 drives the multiplexers 5, 6 in such a way that - generally speaking:

a) the components of the CAN module whose state is represented by the data stored in the storage element sets 2, 3 are connected to the first storage element set 2 via the first multiplexer 5, and

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b) the jointly utilized components of the CAN module are connected to the first CAN bus A (node Node A) via the second multiplexer 6,

10 if, on the part of the first CAN bus A, a request to the jointly utilized components of the CAN module is present, and that

15 c) the components of the CAN module whose state is represented by the data stored in the storage element sets 2, 3 are connected to the second storage element set 3 via the first multiplexer 5, and

20 d) the jointly utilized components of the CAN module are connected to the second CAN bus B (i.e. node Node B) via the second multiplexer 6,

if, on the part of the second CAN bus B, a request to the jointly utilized components of the CAN module is present.

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In the manner described, the BSP unit BSP can alternately operate two CAN buses (nodes). The use of a single BSP unit for a plurality of CAN buses (nodes) is non-critical because, as has already been mentioned above, the BSP unit BSP is
5 subject only to relatively low capacity utilization.

In order to ensure that the BSP unit BSP can react as rapidly as possible to BSP requests on the part of the BTL units that are to be operated by it, it may be provided that the BSP unit
10 BSP calculates, and buffer-stores, the possible reactions to events that are intended to provoke reaction actually in advance, i.e. before the occurrence of the relevant event. If the relevant event then occurs, reaction to it can be provoked simply by outputting or implementing the reaction calculated
15 in advance.

This can be used in particular, but not exclusively, for the reaction of the BSP unit BSP to data received from the BTL units. The BTL units expect, at least partly within a
20 predetermined time, a reply to data (data bits) which they have transmitted to the BSP unit, this reply depending on the state of the BSP unit and the value of the relevant data bit. If the advance calculation of the reply is carried out at a point in time at which that state of the BSP unit which is
25 critical for the reaction thereof can no longer change before reception of the data bit to which it is necessary to react,

then the reaction that is to be performed by the BSP unit depends "only" on the value of the data bit to which it is necessary to react. Since the value of a data bit can only be either 0 or 1, the possible replies can be determined

5 completely in advance without any difficulty. The two possible replies (one for the case where the next data bit received has the value 0, and one for the case where the next data bit received has the value 1) are buffer-stored and output as required, i.e. when the relevant event occurs, 10 which, understandably, is possible within a very short time and reliably precludes a belated reaction of the BSP unit.

The CAN module described can be used in the manner described without any difficulty, as a shared CAN module for a plurality 15 of CAN nodes.